(*Pamphlet No. 27*)

TANGANYIKA TERRITORY

DEPARTMENT OF AGRICULTURE

Sixth Annual Report of the Coffee Research and Experiment Station, Lyamungu, Moshi 1939

IMPERIAL MYCOLOGICAL INSTITUTE
21 APR 1942

1941
DAR ES SALAAM
PRINTED BY THE GOVERNMENT PRINTER
Price Sh. 1/50 (1s. 6d.)

46781/12-41/1c

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COFFEE RESEARCH AND EXPERIMENT STATION, LYAMUNGU, MOSHI

Report for the period 1st January to 31st December 1939

Section I.—ADMINISTRATION

Staff List

Chief Scientific Officer in general charge.—S. M. Gilbert, B.SC., N.D.A., DIP. AGRIC. (WYE).
Plant Pathologist.—G. B. Wallace, B.SC., PH.D.
Entomologist.—F. B. Notley, M.SC., A.I.C.T.A.
Chemist.—H. B. Stent, M.SC., A.I.C., A.I.C.T.A.
Agricultural Officer.—R. B. Allnutt, B.SC. (AGRIC.) (LOND.).
Agricultural Assistant.—L. M. Fernie (Plant Propagator).
European Clerk.—C. H. Taylor.
Senior Recorders.—I. Thomson; W. Poppleton; K. Johansen; J. C. van Schoor.

Staff Changes

The Chief Scientific Officer departed on vacation leave on 4th May, from which date the Plant Pathologist assumed charge of the Station. The Chemist departed on vacation leave on 21st June. Mr. Allnutt assumed duties at the Station on 8th January and was transferred, on the 9th November, to Tanga for sisal control work due to the outbreak of war. As a temporary measure the duties of Agricultural Officer were then carried out by Mr. G. Milne, Soil Chemist, Amani, who arrived at the Station on 1st November. Mr. K. Johansen was seconded for duty with the King's African Rifles at the outbreak of war. Messrs. I. Thomson and J. C. van Schoor were also called out for special police duties in Moshi at the beginning of September. Mr. W. Poppleton resigned his appointment on 13th December. Mr. C. H. Taylor was seconded to the Custodian of Enemy Property Department as from 1st November.

Leave movements during the year.—Mr. S. M. Gilbert : departed 4th May 1939 and is due to return January 1940; Mr. H. B. Stent : departed 21st June 1939 and is due to return February 1940.

Finance

Financial assistance, which is gratefully acknowledged, was obtained for a further period of five years from Colonial Development Funds. It amounted to £3,750 in 1939. This sum was increased by a further amount of £1,536 from departmental votes to enable recurrent expenditure of the Station to be met for the year.

Revenue amounted to £259 6s. 0d., of which approximately half was from the sale of coffee and the remainder receipts from the staff for lighting, water and milk.

Special funds were made available for the construction of the necessary field works for experiments in the irrigation of coffee and eleusine.

Visitors

Scientists from places as diverse as Holland and Hong Kong, Abercorn and Addis Ababa paid visits.

Publications

Articles submitted to the *East African Agricultural Journal* during the year were : "Some further observations on Thrips", "Plant Diseases Spread by Bugs", "A Non-parasitic Disease of Arabica Coffee", "Control of Smut Diseases—A Review of Recent Literature", "French Bean Diseases and Bean Fly in East Africa" and "The Rooting of Softwood Cuttings of *Coffea Arabica*."

Miscellaneous

While on home leave the Chief Scientific Officer attended the International Congress of Genetics and spent some time with members of the "coffee trade" in London. He also attended the Inter-territorial Coffee Research Committee meeting in Nairobi.

Station Development

Progress under the above heading is set out below :—

Table I

How occupied	Acres	Change
Coffee :—		
(a) under three years	38	
(b) over three years	26	+ 13
Nurseries	7	
Bananas and fodder grasses	20	+ 6
Paddocks	14	+ 5
Coppices and wind belts	26	
In preparation for experiments	50	— 41
Forest	30	
Roads, buildings, etc.	27	+ 1
Light bush—uncleared	44	— 12
Labourers food gardens	28	+ 28
Total ...	310	

The area under coffee was increased by thirteen acres, including the completion of the planting of formal trials of thirty-five seedling coffee selections.

Some twenty acres were cleared, anti-erosion works completed and land marked out for trials of clonal coffee selections. This area will be used for the production of food crops as a war measure until clonal material is ready. Fodder crops were extended.

About a mile of service roads were constructed to facilitate movements of material.

Meteorology

The total rainfall for the year was 1,761 millimetres (69 inches). Rather heavy long rains fell from April to June amounting to 1,530 millimetres (60 inches). The short rains unfortunately completely failed. No rainfall amounting to half an inch fell in any one day during the entire last six months of the year. The effects of this bad distribution on planting and on field experiments can readily be imagined.

Improvement of Plant Material

Six years records have been completed on about a hundred trees.

Liquoring was carried out on all the 1938 selections by Mr. Devonshire of the Kenya Coffee Board staff. Great appreciation is accorded to the Board for this service. Seedling progeny (open pollinated) of some of these selections are under trial at this Station, at Mbosi Sub-station and on six estates.

Cultural and Manurial Investigations

Records were completed on almost all of the experiments mentioned in the 1938 report. The outbreak of war in September, and the subsequent calls on the staff did, however, create difficulties which were not entirely overcome. Moreover the internment of certain alien planters led to treatments not being carried out as planned.

Accumulation of useful data from experiments on the Station proceeded normally but, for the above reasons, the tabulation and computation of the results of these experiments were delayed for some months.

Vegetative Propagation

In this section real progress can be recorded and Mr. Fernie is to be congratulated on rooting nearly seven thousand cuttings. These are sufficient to plant four badly needed experiments with clonal material.

Soil Investigations

The Chemist has studied the rate of nitrification of sulphate of ammonia applied to local soils in time of heavy rainfall and the rate of leaching of the nitrate formed. He has also demonstrated how quickly the base status of these soils is reduced by heavy annual dressings of this fertilizer.

Plant Pathology

In connection with *Hemileia* studies, the field observations on vegetative characters on sprayed and unsprayed trees, commenced in August 1938, were continued during 1939. Examination of the data obtained is now in progress, and results will be published in *Quarterly Notes*.

Entomology

Work on the leaf-miners continued. In the previous report it was suggested that the fundamental cause of outbreaks was the dominant stage of the host, and investigations were concentrated on the method of initiation of this dominant stage. Evidence has been found that the dominant stage is a permanent phenomenon in both species, persisting from one outbreak to another. In this area therefore the parasite complex is such that outbreaks of greater or less severity are normal. Further work has been aimed at obtaining a full understanding of the complex, with a view to some modification (by introduction of certain other parasites or otherwise) which will alter this state of affairs.

The correlation of population density of *Antestia* and percentage damage of crop has been continued, together with studies of seasonal incidence and control of this pest.

Lyamungu,
March 1940.

S. M. Gilbert,
Chief Scientific Officer

Section II.—IMPROVEMENT OF PLANT MATERIAL

Records of yield in cherry of some hundreds of trees, which are potential selections, have been completed, in many cases for six successive years. Over one hundred trees have been further examined for "out-turn." This involves the measurement of adequate samples from each tree in respect of amount of parchment and clean coffee per unit sample of cherry; the percentages by weight of clean beans passing through screens of various sized meshes and width of bars, corresponding to commonly used screens in the curing works; weight of bean and density. Most of these hundred selections will be tested for quality by a competent liquorer.

Of all the trees so far examined only three meet all our requirements, that is, they are outstandingly good in respect to yield, regularity of yield, "out-turn", compactness of bean and liquoring quality. Five more are very good in respect to one of the two main qualities needed, yield and liquoring quality. Seven additional ones are quite good in regard to both qualities. A further useful class has first rate quality although the yield may not be good. This type might prove useful for grafting or budding purposes.

A summary of these trees is given in the table below :—

Table II

Class	Tree No.	Average Yield Clean coffee per acre	Liquoring quality
I	*L1	22·2	Good to Fine
	*N39	21·5	„
	*N197	17·8‡	„
II	*N17	18·8	„
	*N18	18·0	„
	*N100	17·3	„
	*R3	23·6	Fair to Good
	*N34	20·2	„
III	*I56	20·1	„
	*N5	17·8	„
	*N53	17·4	„
	*N215	17.6	„
	*N219	19·0	„
	†R1	18.4	„
	†R2	18·9	„
IV	N128	Fair	Good to Fine

*Six years. †Five years. ‡ Heavily pruned for cuttings.

Owing to the absence on home leave of certain of the staff the work on density in relation to quality was held over.

The seedling progeny (open pollinated) of all the potential selections referred to previously are under trial at the station, at Mbosi sub-station and on six estates.

S. M. Gilbert,
Chief Scientific Officer

Section III.—VEGETATIVE PROPAGATION

The rooting of softwood cuttings has taken precedence over other methods of vegetative propagation and the methods are essentially the same as those set out in my annual report for 1938. The full technique has been described in an article submitted for publication in the *East African Agricultural Journal.* Actual experimental work has been limited and a concentrated effort made to produce large numbers of rooted cuttings of certain clones for subsequent use in field experiments. The taking of cuttings of selected trees has continued and a clonal selection nursery has been started in which it is hoped to plant out at least twenty rooted cuttings of each selection; these will be used as mother-trees for the production of the necessary quantity of cuttings for clonal variety trials in the field.

Experiments have been confined to trials with rooting media to which great importance is attached; these have been fully reported elsewhere.* Briefly, peat moss is the most suitable organic material tried so far. It should be mixed with a coarse sand in the proportion of 2 : 1 by volume. Unfortunately this is expensive and is not easily obtainable. Coconut fibre, which is much cheaper and more readily available in tropical countries, can be used as a substitute for peat moss, although it is not so efficient and cuttings set in it take longer to root. When used, coconut fibre should be well rotted, broken up, and sifted and is best mixed with a coarse sand in equal proportions by volume.

Details of all cuttings handled during 1939 are shown in Tables III (a) and (b).

Table III (a)

	Cuttings				Died After Rooting			
	Taken and set 1939	Taken 1939 rooted 1939	Taken 1938 rooted 1939	Total rooted 1939	Rooted 1939 died 1939	Rooted 1938 died 1939	Total 1939	Average number of weeks to root
January ...	733	—	265	265	1	26	27	24·27
February ...	1570	1	251	252	2	30	32	24·02
March ...	1564	6	231	237	5	18	23	21·66
April ...	1906	22	272	294	21	29	50	24·01
May ...	2163	170	544	714	4	5	9	26·18
June ...	724	417	285	702	18	2	20	22·51
July ...	1560	464	251	715	63	2	65	24·92
August ...	1701	606	236	842	15	—	15	24·65
September	451	850	220	1070	—	—	—	27·51
October ...	1073	631	119	750	337	1	338	27·48
November	1358	250	69	319	122	—	122	31·53
December...	839	560	82	642	301	—	301	29·96
Total ...	15,642	3,977	2,825	6,802	889	113	1,002	26·05

Table III (b).—*Summary*

	Cuttings taken	Percentage Rooted 1939	Percentage Died 1939	Percentage Alive but unrooted at 31.12.1939
1939	15,642	25·42	27·31	47·27
Unrooted from 1938 ...	6,383	44·26	50·42	5·32
Total ...	22,025	30·88	34·01	35·11

**Quarterly Notes* Nos. 9 and 11, for March and September 1939 respectively.

It will be seen in Table III (a) that 75 per cent of the deaths of rooted cuttings occurred in the last quarter of the year; altogether 13 per cent of those rooted in 1939 died subsequently during the year. This has been a serious setback. Because of the number of changes of environment and transplantations that a young rooted cutting has to undergo, a certain number of deaths are inevitable, but they should not exceed a small percentage of the total number rooted. The majority die during the intermediate "hardening off" period after removal from the frames but prior to planting out in the open nursery. The reasons for this are still under investigation.

It must be remembered that any results given for the whole year include those where cuttings have been purposely subjected to unfavourable conditions or where the cuttings themselves have been unsuitable. Thus, whereas in Table III (b) it is shown that the percentage number of deaths still exceeds that of the number rooted, Table IV gives an idea of the results that can be obtained under particularly favourable conditions.

TABLE IV

Treatments	Rooted	Died	PERCENTAGE Alive but unrooted after 6 months	Mean number of weeks to root
Peat moss—sand 2 : 1 ...	87·37	5·26	7·37	15·31
„ „ — „ 1 : 1 ...	83·16	6·32	10·52	15·85
Coconut fibre—sand 2 : 1	67·37	10·53	22·10	19·69
„ „ — „ 1 : 1	63·16	5·26	31·58	17·55
Mean ...	75·27	6·84	17·89	16·91

These figures (in Table IV) are taken from the results of the best block in the second trial of rooting media referred to above, and show that it is possible to get 87 per cent rooted and only 5 per cent dead during a period of six months. The mean of all four treatments in this block gave 75 per cent rooted and only 7 per cent dead and the mean number of weeks taken for these to root was seventeen.

It has been the practice here to retain all cuttings in the propagating frames until they either root or die. The number of weeks that each cutting took to root during 1939 is shown in Fig. 1, any time over one hundred weeks being recorded jointly. These are figures for all cuttings rooted throughout the year. From the graph it can be deduced that it is not advantageous to give cuttings their initial examination for roots until ten weeks have elapsed from date of setting. It can be seen that the majority (62 per cent) of those cuttings which rooted did so within the space of six months from the date of setting and after that time there was a steady falling-off; within a year from date of setting some 96 per cent had rooted. At present, under favourable conditions (for example, in a peat moss/sand medium) and provided that there is unlimited material available, it is considered advisable to discard all cuttings unrooted after six to seven months in the propagating frames. Under less ideal conditions (for example, in a coconut fibre/sand medium) it cannot be considered economical to retain cuttings unrooted for more than a year.

Two new blocks of frames, each block containing six compartments arranged back to back in two rows of three, have been constructed to facilitate the rooting of cuttings required for the Irrigation Experiment XV. They are

similar to the original ones described in a previous report,* as these have proved to be the most satisfactory type. A more permanent structure of iron and wire-netting has been erected over the frames to support the hessian which is used for artificial shade.

Lyamungu,
March 1940.

L. M. Fernie,
Agricultural Assistant

Section IV.—CULTURAL AND MANURIAL INVESTIGATIONS

Recording of yields of certain blocks on several estates have continued with the object of providing material of known behaviour for subsequent experiments. Details are not given in this report but Table V presents a frequency distribution of yield of all non-experimental trees recorded.

Table V.—*Frequency Distribution—all Uniformity Trials Plots*
1939—Kilograms of Cherry

Kilograms	–2	–4	–6	–8	–10	–12	–14	–16	–18	–20	–22	Trees Total
No. of trees	5,411	1,581	596	397	276	181	100	34	12	7	1	8,596

— =less than

Briefly the figures confirm previous results, that is, that the major part of the crop was given by a minor number of trees; to particularize: 20 per cent of the crop was given by 5 per cent of the trees or 66 per cent of the crop by 25 per cent of the trees. It follows that about 75 per cent of the trees were uneconomic.

Manurial Co-operative Experiments on Estates

1936 Series. Estate B.—The following are the results to date from one of the "1936 series" manurial trials:—

Table V a.—*Yields in cwts. clean coffee per acre*†

Year	No Treatments A	B	C	D	Mean	Significant difference
1934	1·11	1·55	1·17	1·36	1·30	—
1935	6·83	7·73	6·87	7·11	7·14	—

	Treatments Ammonium Sulphate	Elephant grass	Compst	Nil		
1936	4·71	5·70	4·77	4·96	5·03	—
	Guinea grass					
1937	5·58	5·58	7·38	5·81	6·09	—
	Ammonium Sulphate and compost					
1938	**4·55**	**5·02**	3·76	3·87	4·30	0·57
1939	**8·38**	4·90	4·72	3·85	5·46	1·50
‡Means of 1936-1939 corrected on 1934-35	**5·93**	5·07	5·24	4·62	5·22	0·67

*Annual Report 1935.

†Calculated at twelve per cent clean to cherry. Figures **underlined** pass the accepted statistical tests. This means that the probability is not less than twenty to one that the differences in yield are due to the treatments applied.

‡Calculated by method of co-variance with previous natural yields.

There is an indication that compost applied just *before the long rains is useful.* This was done only in 1937 because of practical difficulties on the estate. Applied at the end of the rains (1938 and 1939) it does not appear to be so effective.

Sulphate of ammonia has been successful in 1938 and 1939, outstandingly so in the latter year.

The combined analysis for all years shows strong different effects of the same treatment under various climatic conditions. The intensity, as well as the amount of rainfall is very important. Much further study of the interactions between treatments and seasons is required. It has been confirmed that under certain rainfall conditions the supply of nitrogen necessary to a good crop is washed beyond root range. This must be replaced. Further study as to the correct time of application of organic manure is required.

1937 Series. Estate E.—Thatching grass has helped in both 1937 and 1939. It is probable that this benefit is due to the conservation of moisture which fell in the long rains. The soil in this estate is not very retentive. The planter had made a practice of "continuing" the long rains by means of irrigation.

TABLE V B.—*Yields in cwts. clean coffee per acre**

Year	No Treatments A	B	C	D	Mean	Significant difference
1934	0·63	0·90	0·54	0·62	0·67	—
1935	9·17	10·49	7·87	8·25	8·94	—
1936	4·91	5·68	4·20	4·43	4·80	—

	Treatments Farmyard manure	Thatching grass	Guinea grass	Nil		
1937	3·38	**5·19**	3·80	3·64	4·00	1·45
1938	**5·18**	3·93	3·99	4·66	4·44	1·14
1939	1·96	**2·65**	1·76	1·60	1·99	0·54
†Mean of 1937-39 corrected for 1935	2·65	**3·83**	2·84	2·66	3·0	0·61

EXPERIMENTS ON STATION

Yields in 1939 were low throughout the station and the results are too small to be significant. In most cases, therefore, means of two years' yield are given.

Experiment I—Method of planting.—Table VI below confirms that planting at nursery level is best but preparation of holes has not yielded similar results to those of 1938. Good preparation of holes seem to have had the effect of forcing on the coffee in 1938, causing it to overbear, and, *in the absence of sufficient reduction of crop, done harm.* This matter requires serious attention.

*Calculated at twelve per cent clean to cherry. Figures in bold type pass the accepted statistical tests.

†By method of co-variance.

TABLE VI.—*Yield results—1938 and 1939*

Clean coffee per acre, in cwts.*

	No. Holing	† H3F1	‡ HF1	Hole Subsoiled Without Compost H3F1	Without Compost HF1	With Compost H3F1	With Compost HF1	Mean
Deep Ball								
1938	6·52	**7·74**	4·21	6·99	4·80	6·65	6·63	6·22
1939	1·72	1·43	1·53	1·01	0·86	0·86	1·44	1·26
Mean ...	4·12	4·58	2·87	4·00	2·83	3·76	4·03	3·74
Deep Bare								
1938	6·35	6·43	5·76	**7·64**	6·13	**7·47**	5·70	6·50
1939	1·24	0·81	1·07	1·24	1·02	0·78	1·53	1·10
Mean ...	3·80	3·62	3·41	4·44	3·57	4·13	3·62	3·80
Nursery Ball ...								
1938	6·71	**9·20**	7·01	**8·23**	7·17	**10·23**	6·43	**7·85**
1939	**3·20**	1·23	1·23	1·31	**2·24**	0·75	1·77	**1·68**
Mean ...	4·91	5·21	4·12	4·77	4·70	5·49	4·10	**4·76**
Nursery Bare								
1938	7·07	**8·23**	5·60	**8·24**	6·36	**8·82**	6·34	**7·29**
1939	**2·26**	1·07	1·88	1·12	1·99	0·91	1·17	**1·44**
Mean ...	4·66	4·65	3·74	4·68	4·17	4·86	3·75	**4·36**
Main Treatments								
1938	6·66	**7·90**	5·65	**7·78**	6.11	**8·29**	6·27	6·95
1939	**2·11**	1·13	1·43	1·17	1·53	0·82	1·48	1·38
Mean ...	4·38	4·51	3·54	4·48	3·82	4·56	3·87	4·17

	1938	1939	Mean
Significant differences in the results are:—			
(1) for the preparation of holes	1·70	0·75	—
(2) „ „ methods of planting	0·82	0·33	0·44
(3) „ „ interactions	2·98	1·25	—

Figures in bold type pass the accepted statistical tests.

Girth measurements confirm the superiority of planting at nursery level.

Experiment II—Seedling selection trials.—Nearly one hundred potential seedling selections are being formally compared in this area. Owing to the six months of drought in the latter half of the year there is a large percentage of casualties. Ample similar material is, however, in reserve in the nurseries for supplies.

Experiment III—Comparison of clones and seedlings from same trees.—This experiment is completely planted and being trained in readiness for grafting next year.

Experiment IV—Seeding stocks for grafting.—Grafting will begin in this area in 1940. Certain exotic coffees of species other than Arabica and Robusta are definitely failures and must be replaced.

Clonal selection trials.—An area of some twenty acres has been reserved for these experiments. The bush has been cleared and the land cleaned and anti-erosion measures have been completed. The area will now go under beans for probably two years. It is not anticipated that sufficient clonal material of selections will be ready before 1942.

*Calculated at twelve per cent clean to cherry.

†H3F1 =holed three months before planting and holes filled one month before.

‡HF1 =holed and filled one month before planting.

Experiment V—Fertilizer trial.—This experiment has been recast in a form more in accordance with the latest technique. Clonal material is being used. Messrs. The Imperial Chemical Industries, Ltd., are supplying the sulphate of ammonia free. The land is ready and planting awaits the onset of the rains.

Experiment VII A—Conversion of single stem to multiple stem coffee.—A small crop has set on the new suckers of all methods. Mortality is greatest in the clean stumped plots. At present, the method by which the original trees were cleared of all primaries except the top three pairs seems the most promising.

Experiment VIII—Soil erosion demonstration.—The results from this experiment are becoming less pronounced. Even the clean weeded plots are tending to form ridges across the slope. Erosion is also less all round because the coffee trees themselves almost meet and afford a good deal of ground cover. The exception is in the erect cover crop plot (7) where a good deal of "die-back" occurred. In this plot nearly two and a half tons of soil was lost. To see if the "die-back" was directly caused by the cover crop, a "weeds across the slope" plot (3) has been altered to "erect cover crop." Table VII sets out the results.

TABLE VII.—*Yield per acre, in cwts.*

Eroded soil—Tons per acre

Plot No.	1938		1939		Mean	
	Yield	Soil	Yield	Soil	Yield	Soil
(1) Clean Cultivation	3·87	2·90	1·83	0·74	2·85	1·82
(2) Contour hedge	4·85	1·84	1·37	0·30	3·11	1·07
(3 & 8) *Weeds across slope	7·16	1·57	1·17	0.86	4·16	1·22
(4) Contour hedge and cover crop	4·94	1·44	0·96	0·26	2·95	0·85
(5) Banana mulch	8·17	1·02	1·72	0·16	4·94	1·18
(6) Procumbent cover crop	5·20	0·94	0·91	0·18	3·05	0·56
(7) Erect cover crop	4·83	3·72	0·74	1·27	2·78	2·49
Mean	5·57	1·92	1·45	0·63	3·51	1·27

*Mean of two plots

Experiment IX—Methods of cultivation.—Yields this year were negligible. The plots receiving "jembe" and "fork jembe" treatments are superior in growth.

TABLE VIII.—*Yield per acre, in cwts.*

	1938	1939	Mean
Fork Jembe	4·31	0·20	2·25
Jembe	4·33	0·36	2·35
No cultivation	4·19	0·31	2·52
Envelope Forking	3·40	0·26	1·83
Trenching	1·47	0·34	0·90
Mean	3·54	0·29	1·92
Significant difference	1·47	—	0·82

Trenching has given yields lower than all others (P = ·01).

Experiment X—Artificial shade.—The clones on this experiment will bear their first crop in 1940, from then on, yields and growth measurements will be recorded. At present there is nothing to report.

Experiment XI—Comparison of Kent's and Bourbon coffee.—The yields are given below. The differences are not significant. Kent's coffee gives an appreciably larger bean. The liquoring qualities of both received very good reports.

TABLE IX.—*Yield per acre, in cwts.*

Year	Kent's	Bourbon	Mean
1938	7·69	7·12	7·40
1939	4·86	3·11	3·98
Mean	6·27	5·11	5·69

Experiment XII—Type of plants.—Table X indicates that, up to date, selection in the nursery of the most vigorous seedlings still has a beneficial effect.

TABLE X.—*Yield per acre, in cwts.*

	1938	1939	Mean
Roots good, Tops cut back	2·12	0·60	1·36
Roots good, Tops good	4·31	0·55	2·43
Roots average, Tops average...	3·04	0·42	1·73
Roots poor, Tops good	3·45	0·47	1·96
Roots good, Tops poor	2·73	0·42	1·57
Roots poor, Tops poor	2·15	0·52	1·34
Mean	2·97	0·50	1·73

Experiment XIII—Comparison of multiple and single stem trees.—There are three replications for this experiment. The combined results for the first crop are as follows :—

TABLE XI.—*Yield per acre, in cwts.*

	1938	1939
Single Stem	Fly crop— ...	1·74
Multiple Stem, Agobiada	Insufficient ...	**0·41**
„ „ three suckers	for ...	1·76
Mean	comparison ...	1·30
Significant difference	...	0·73

Figure in bold is significantly lower than the others.

Examination gives clear indications that the Multiple Stem system (three suckers) yields a larger percentage of clean coffee to cherry than either the Agobiada method of obtaining multiple stem or the single stem, and the bean is definitely larger.

Experiment XIV—Mulch treatments.—There is, as has been observed in Uganda also, a tendency for mulches to force overbearing. This must be counteracted by regulating the crop.

TABLE XII.—*Yield per acre, in cwts.*

Treatments	Yield 1938	1939	Mean
Banana mulch	**5·07**	0·49	2·78
Grass mulch	**3·13**	**0·93**	**2·03**
Banana mulch and Ammonium sulphate (a)	1·68	0·68	1·18
Elephant grass (b)	1·31	0·29	0·80
Clean weeded	1·88	0·26	1·07
Weeds as mulch	2·10	0·34	1·22
Elephant grass plus Ammonium sulphate (c)	1·47	0·29	0·88
Clean weeded plus compost	2·05	0·37	1·21
Mean	2·34	0·46	1·40
Significant difference	0·85	0·44	0·43

Yields in bold are significantly higher than all others.

(a) Crotalaria in long rains until 1938.
(b) Crotalaria in short rains until 1938.
(c) Crotalaria in long and in short rains until 1938.

The new treatments (1938) involving sulphate of ammonia and elephant grass have not yet had time to counteract the ill-effect of the previous cover crops.

Experiment XV—Irrigation.—The headworks and flumes have been constructed with the assistance of the Hydrographic Survey Department and plots have been levelled. Clonal material is available so the experiment is thus ready for planting in the next long rains.

Experiment XVII—Age.—The 1939 plantings have been completed. There will be a "fly" crop on the 1937 plots in 1940.

Native demonstration area.—This area is designed to show the good effects of certain simple operations such as measures against soil erosion and thinning of banana shade. The first crop will be next year.

Plantation demonstration—1937 planting.—This area is looking very well. The measures taken against soil erosion (terracing) have been very effective. The shade of several different types of tree is being carefully regulated. A first crop has set.

THE STATION—MISCELLANEOUS

Stock

Cattle.—The policy of building up the herd entirely from the animals bought originally in 1935 has continued. With the exception of one bull, no further purchases of cattle have been made. At the end of the year the livestock was at the following strength :—

Cows	10	Heifers	7
Bull	1	Heifer calves ...	4
Oxen and steers ...	7	Bull calves ...	8

To equalize the milking periods the cattle now graze until 5.30 p.m.

Donkeys.—Six donkeys were purchased and are being used for the transport of fodder and compost.

Fodder grasses and Mulch materials.—Areas under elephant grass, guinea grass and bananas have all been extended. Two experiments in time of cutting of the above two grasses have been laid down. Cutting at different intervals will begin as soon as the stands are sufficiently uniform. It may be noted that in a period of six weeks ending early April the elephant grass reached six feet in height after low cutting. Immediately after cutting the plots will be cleaned, supplied where necessary, and receive a light dressing of sulphate of ammonia. A strain of giant guinea grass is being extended.

Paddocks.—As opportunity occurs paddocks are being stumped and fenced and in due course rotational grazing will begin.

A strain of giant *Cynodon*, introduced from Kenya, shows promise and is being extended.

Lyamungu,
April 1940.

S. M. Gilbert,
Chief Scientific Officer

Section V.—REPORT OF THE CHEMIST

Nitrification studies—Action of ammonium sulphate.—Much attention has been focussed on the nitrogen status of coffee soils. In the Northern Province, particularly, soils are so well supplied with mineral plant foods that available nitrogen and moisture are generally likely to be the limiting factors in plant nutrition.

The use of ammonium sulphate in order to make good the natural supply of nitrate, which is transported below the root zone by heavy rainfall, looms large in our experimental programme. The fate of this fertilizer when applied to a Kilimanjaro clay loam soil during the middle of the long rains has now been investigated. This soil is neutral in reaction, rich in bases and phosphate and fairly rich in humus.

The fertilizer was applied at the rate of six hundredweights per acre in the middle of the long rains, viz., on 6th May : most of the soil nitrate had then been leached to a depth of four to five feet by the April rains. The plots treated were weeded at the time, but not cultivated. Subsequent weed growth was negligible and therefore absorption of added nitrogen by plants is eliminated from the discussion. Samples of soil were taken periodically for the determination of ammonium ion and nitrate ion.

Very little, if any, of the fertilizer is leached as such. The ammonium ion is fixed in the surface soil and progressively converted into nitrate : the nitrate formed is liable to be leached downward into the subsoil. The rate of these changes is shown in Table I.

Table I

Days after application of Sulphate of ammonia	Rainfall since application	Percentage added nitrogen remaining in surface soil as		Percentage added nitrogen leached as ammonia or nitrate
		Ammonia	Nitrate	
11	14·5 inches=368 mm.	83	7	10
24	20 inches=508 mm.	23	22	55
37	25 inches=635mm.	2	9	89

In the course of thirty-seven days, during which 25 inches of rain fell, practically all the ammonia was converted into nitrate, most of which was leached into the subsoil. Samples of soil taken at different depths showed the following distribution of nitrate at the end of the period of the experiment :—

Table II

Depth of sample		Percentage of added nitrogen found in form of nitrate
0— 6″	...	9
6—12″	...	6
12—18″	...	11
18—24″	...	21
24—36″	...	42

Apparently 70 per cent of the added nitrogen was transported below the top foot of soil and 60 per cent below the 18-inch level.

Effect of cultivations on nitrate production.—As in 1935, periodical tests were made to see the effect of different methods of cultivation on the resumption of nitrification during the period following the long rains of 1939 (Experiment IX). Cultivation with fork jembe, or with jembe, or burial of weeds in trenches all proved efficacious in stimulating nitrate production as compared with no cultivation or the use of envelope forks.

Effect of ammonium sulphate on soil reaction.—The continued use of ammonium sulphate is known to increase soil acidity. To what extent this occurs has been studied on experimental plots which had received heavy applications of the fertilizer for three years in succession. Before the experiment was started the soil reaction was pH 6·4. After three annual applications the pH of the top soil was reduced to 5·3. The corresponding reduction of exchangeable bases was from 18·3 to 13·7 milligram equivalents per cent, i.e., 25 per cent of the exchangeable bases of the surface soil were removed in three years. If the original base status of the soil is to be maintained it will be necessary to alternate the use of ammonium sulphate with nitro lime or sodium nitrate.

Alkali soils.—Further work has been done on the more alkaline soils of Mount Meru. Two sites where coffee has failed were examined and found to contain appreciable accumulations of alkaline carbonate in the deep subsoil.

Boron investigations.—The possibility that excessive amounts of boron might be the cause of the failure of coffee in some of the volcanic ash soil has been considered. The analysis of leaf material from healthy and unhealthy trees has, however, failed to reveal excessive quantities of boron in the unhealthy trees.

Survey.—A soil profile at an altitude of eight thousand feet on Mount Meru was examined.

Miscellaneous analyses undertaken include :—

	Samples
Timbers for moisture content	4
Compost	2
Cattle manure	1
Pyrethrum	1
Saline earth (for nitrate)	1

Lyamungu,
March 1940.

H. B. Stent,
Chemist

Section VI.—REPORT OF PLANT PATHOLOGIST

Coffee

Hemileia.—This disease of coffee remains the major subject for investigation. The two spray experiments referred to in the 1938 annual report were continued. Spraying was done in February, and the four-weekly observations on twig-growth, leaf-fall, and disease incidence were continued. The experiments have been referred to in the above report and in the *Quarterly Notes* of the Coffee Research Station for March 1939.

A modification in the 1939 spray programme was the increase in the amount of Cuprous oxide used to 3·3 pounds per hundred gallons. At that strength more encouraging results have been obtained and present indications are that this fungicide will compare favourably for results and cost with 1·0 per cent Bordeaux mixture.

Observations have not been made for a sufficiently long period for differences in crop resulting from spray treatments to be observed, but effects on vegetative characters are of interest. These will be dealt with in detail when the figures for both experiments have been examined. So far only the experiment in which three treatments are compared with unsprayed controls has received preliminary examination.

The treatments (A, B and D) are 1·0 per cent Bordeaux mixture (A), 0·5 per cent Bordeaux mixture (B), and a proprietory form of Copper Hydroxide (D). C is the control. The figures for various vegetative characters have been graphed but have not yet been examined statistically. It is found that A and B are equally effective in *Hemileia* control, while D is not effective,—in its effects on vegetative characters D is scarcely different from the control C.

Conclusions as regards time of spraying, under the conditions of the experiment, are as follows :—

The end of February is the best time for spraying, especially if the trees have not been previously sprayed, for the following reasons : (a) weather conditions are still favourable, i.e., dry; (b) there are fewest leaves on the trees at that time : less spray fluid is required, and all the leaves are comparatively easily reached; (c) both the number and the percentage of infected leaves is low; and (d) the peak for leaf-fall has passed (although it still continues till the end of April, especially in previously treated trees).

The end of November is indicated as the best time if a second spraying is to be given, since at that time the number and percentage of infected leaves is again low. In previously treated trees it has the advantage that it precedes an increase in numbers and percentage of infected leaves, and in previously untreated trees it coincides with a heavy growth of new leaves.

Present indications are that full strength (1·0 per cent) and half strength (0·5 per cent) Bordeaux mixture have equal effects; the latter is, of course, cheaper for chemicals. Should it be intended nevertheless to apply the full quantity of chemicals, it would appear more beneficial to apply half strengths

at the end of February and the end of November. Details of experiments will be given in *Quarterly Notes* or in a separate communication.

Leaf-fall.—An unusually heavy fall of leaves on coffee growing on the ash soils of Meru, and its control by Bordeaux mixture was discussed in *Quarterly Notes* of the Coffee Research Station for September 1939. A detailed investigation is planned for 1940.

Other Crops

Banana.—This crop which is widely grown for local native consumption is remarkably free from major diseases. In June 1939, *Cercospora* leaf-spot, also known as *Sigatoga* disease, was reported at several points on the coast south of Dar es Salaam, and later on the plain south-east of Korogwe, and near Pugu, on the Central Railway. The significance of the disease and control measures are discussed in Mycological Circular No. 5 which is obtainable from the laboratory.

Sisal.—Two non-parasitic sisal diseases were examined on estates near Lindi in March-April. Both occur in the hot damp weather after rains. Manurial experiments were suggested and in the meantime it was advised that on the affected areas leaf should be cut before disease is expected to appear.

Beans.—The bean diseases referred to in the previous annual report have been fully discussed in an article published in the *East African Agricultural Journal* in November 1939. The experience this year confirms the presence in a moderate or mild form of bacterial disease and Mosaic. Bean fly is the limiting factor and an important pest in French beans sown with the short rains. These beans when sown during the long rains do not suffer from the pest in the Moshi district so far as present experience shows.

New Records of Plant Diseases in the Territory

Plum trees in the Usambara mountains were found affected by the root parasite *Ustulina zonata*; an unidentified species of Nectria was present in small quantity on the fructifications of the latter.

Apple trees in the Usambaras were affected with Pink disease (*Corticium salmonicolor*).

Green gram leaves were found affected at Lindi by Rust (*Uromyces appendiculatus*) and lucerne on Kilimanjaro by Rust (*U. striatus*).

Cowpeas at Lindi were affected by Mildew (*Erisiphe polygoni*), although Mosaic, previously recorded, is the most severe disease of that crop. Larkspur (*Delphinium* sp.) was affected in the Moshi district by a species of *Sclerotium*.

Lyamungu,
March 1940.

G. B. Wallace,
Plant Pathologist

Section VII.—REPORT OF THE ENTOMOLOGIST

Coffee

Leaf Miner.—Research has continued on the two species involved. The species previously referred to as *Leucoptera daricella* Meyr., has now been described as a new species, *Leucoptera caffeina*. (Washbourne, *Bull. Ent. Res.*, Vol. 30, page 455.) Much the same lines as are described in my annual report for 1938 were followed on the same two areas. Continuous records are thus available for these two areas over two years and observations are still in progress.

This report may be followed more easily if read in conjunction with the popular account of the work given in *Quarterly Notes* of the Coffee Research Station, No. 12 of December 1939, and my annual report for 1938.

Leucoptera coffeella.—Experiment IX is mainly a *coffeella* area; it was shown in fact during the year that increases of *L. caffeina* are probably due to immigration from the neighbouring heavily shaded area. *L. caffeina* would probably disappear from Experiment IX if such fresh infestation did not take place.

At the time of writing the 1938 report, a serious outbreak of *coffeella* was coming under control, the major parasites involved being *Hormius** and *Atoposoma variegatum*, var. *Afra* Masi. Other parasites were of little importance.

The population of *coffeella* continued to fall until May, by which time it was extremely low; less than one egg per tree. From February until the middle of April the percentage parasitism of pupae by *Hormius* remained at between 60 and 80 per cent, while the percentage parasitism of larvae by *A. variegatum* climbed steadily to 75 per cent in February and apparently remained near this figure until the small numbers present by the end of March made it impossible to continue the method. (This method is described in the annual report for 1938.) At the end of April, however, pupal parasitism by *Hormius* fell suddenly to 40 per cent, and to 20 per cent in August, while total larval parasitism, when collection again began to yield useful figures in early September, was down to 13 per cent. As a result of this, the population of *coffeella* began to rise in June, and continued to do so until December. Only a small outbreak resulted however; egg figures reaching three hundred and seventy per tree in mid-December, and this outbreak rapidly came under control. The same parasites were involved in much the same way as in the previous year, though *A. bordagei* was of greater importance in the earlier stages on this occasion than the last.

To quote from my 1938 report: "*L. coffeella* cannot become epidemic in the presence of its parasites except when the host assumes the 'dominant stage' condition. The fundamental control of *L. coffeella* is therefore the prevention of this 'dominant stage'." In this (1939) outbreak the dominant stage is not shown so clearly by the direct evidence of periodic emergence of adults, *vide* Fig. 3 of the 1938 report. The 1939 outbreak was apparently not so markedly

*This is a Braconid described by the British Museum as "Gen. Nov., near *Hormius*"; for convenience it will be referred to as *Hormius* in this report.

dominant stage as the 1938 outbreak, and it seems probable that this is the reason why it was not so severe. A different method of demonstrating the dominant stage was developed as follows : Pupae were collected at intervals from September 1938 onwards; from July 1939 onwards at intervals of three or four days only. Assuming that the time and effort spent in collection were equal on each occasion, the number of live pupae obtained (i.e., pupae subsequently hatching adult moths or parasites) will indicate their relative abundance in the field. Actually the time and effort spent was not equal, but the errors involved need not be discussed here. Fig. 1 shows the number of live pupae collected and the number hatching *coffeella*. During the period of increase of the host, May to November, a series of peaks are shown at intervals approximately those of a generation of *coffeella* at the appropriate temperatures.

It is suggested that these represent times of relative abundance of pupae, and, if they correspond to the period of a generation, they must indicate that the host is in the dominant stage. The amplitude of the fluctuations indicates the intensity of the dominant stage.

These peaks may be traced backwards from May, though with some diffidence. Their positions are also indicated by similar peaks in the percentage of hosts escaping pupal parasitism, the figures for which are inserted in Fig. 1. In this manner, the dominant stage may be traced back to October, with peaks approximately at mid-October, early February, mid-March, and the end of April. The first two peaks preceed peaks of adult emergence in Fig. 3 of the 1938 report.

If this is sound, then the dominant stage of the 1939 outbreak can be connected up with the dominant stage of the 1938 outbreak. It may therefore be that the dominant stage is a permanent phenomenon of *L. coffeella* in this area.

It should be emphasized, however, that the collections from which these conclusions are drawn were made for an entirely different purpose (to determine percentage parasitism only), and there are therefore many possible sources of error. The method has been improved, and observations are being continued. The point is of fundamental importance, since it alters the whole conception of the problem : it suggests that leaf-miner instead of being a pest which is normally under control by its parasites, but which occasionally owing to some curious combination of circumstances goes into the dominant stage, is always to some extent in the dominant stage. The period of increase of the pest causes a reversion towards the normal multiple stage; but the period of control, by differential parasitism, increases the intensity of the dominant stage, and thus lays the foundations of the next outbreak.

There remains still the possibility that the dominant stage is a mere accident, of no economic importance : that outbreaks are due to the curtailment of parasite activity during the cold season. This is supported by the fact that most outbreaks occur in November-December, being initiated during May or June. Further investigations are in progress.

Leucoptera caffeina.—Very considerable advances have been made in our knowledge of *L. caffeina* under the heavily shaded conditions of the area known as Amani Selections. A very severe outbreak took place at the end of November, the number of eggs per tree reaching nearly three thousand five

hundred. This outbreak came under rapid control in January. It appeared to be fairly general over the Lyamungu area. On this occasion the figures for emergencies of adults showed the dominant stage fairly definitely, and this was very well supported by the figures for collections of pupae, Fig. 2, as had been described for *coffeella*.

The previous outbreak of November-December 1938 came under control by February 1939. The number of eggs per tree remained fairly steady at about one hundred and fifty until May, when it fell to only five in the middle of June. This was immediately followed by a sudden rise to three hundred and fifty, and another fall to thirteen by the beginning of August, after which the outbreak developed. Fig. 3 gives the number of eggs per tree over the whole period May 1938 to February 1940.

From collections of larvae only three parasites emerge in large numbers, *Pleurotropis coffeicola* Ferr., *Tetrastichodes leucopterae* Ferr., and *Ageniaspis* species. Fig. 4 shows the percentages of these, and the percentages of unparasitized caffeina, obtained from all collections. It will be noticed that over long periods—May to November 1938 and June to September 1939—larval parasitism was unimportant.

Unfortunately it was not until February 1939 that it was realized that collections of cocoons from the trees yielded practically nothing but *coffeella* and its parasites : collections from fallen leaves on the ground yielded mainly *caffeina* and its parasites.

The pupae can be distinguished and by opening cocoons which have yielded parasites a closer approximation to the parasitism of each species can be obtained, though those which contain only larval remains of the host, and certain parasites such as *Hormius* which push the remains of the host out of the cocoons, are often impossible to determine.

The course of events during 1939 appears to have been somewhat as follows : During February and March *P. coffeicola* and *T. leucopterae* accounted for about 60 per cent of all larvae, while *Hormius* and *Ageniaspis* accounted for a very variable number of cocoons, fluctuating round 60 per cent. (At this time *Ageniaspis* apparently attacked only larvae after they had left the mine and before pupation, though later it attacked larvae in the mine. This parasite has not yet been bred in the laboratory and its behaviour can only be assumed by inference.)

During April the larval parasitism rose to 88 per cent and after this larval parasites disappeared almost completely. At the same time pupal parasitism fell. In June the *caffeina* pupulation, as measured by egg counts, was at minimum, about five eggs per tree; but there was a big increase in July, to three hundred and fifty eggs per tree, accompanied by an increase in larval parasitism by *Ageniaspis*. For some reason this increase was not apparently continued immediately, the numbers of eggs falling to about sixty in August, but thereafter rising to over three thousand per tree by the end of November. From September onwards parasitism had been rising, *Ageniaspis* taking second place to *P. coffeicola* as a larval parasite, and the outbreak came under control during December and January. *Eulophus borboricus* Giard. was of some importance during November.

Pupal collections, as have been described for *coffeella* in Experiment IX, were made in Amani Selections, and the number of live pupae showed very marked fluctuations from the end of May onwards, with somewhat doubtful

fluctuations during March and April. Fig. 2 gives the number of live pupae collected over this period and the number of pupae hatching *caffeina*, together with the percentage parasitism. It will be noticed that the early fluctuations, though faint in the number of cocoons collected, are well marked in the percentage parasitism. It is unfortunate that the records do not go back far enough to show whether they fit with similar fluctuations in the previous outbreak, but by inference from fluctuations in the egg counts it appears that they may well be a continuation of the dominant stage of this previous outbreak. At the least, if the fluctuation in March really indicates a dominant stage of *caffeina* at that time, the host was in the dominant stage when the previous outbreak was only just under control and it seems likely that the dominant stage was actually not lost from one outbreak to the next. If this is so, then the dominant stage is a permanent phenomenon in *L. caffeina* also.

In dissecting cocoons, a good deal of information has been gathered about the inter-relationships of these parasites, which are complicated. A number may be either primary parasites, or secondary or tertiary hyperparasites—or at least superparasites. *P. coffeicola*, for instance, can be apparently a primary parasite of *L. coffeella* or *L. caffeina*, or a secondary of *A. bordagei*, *Hormius*, *Ageniaspis*, or *E. borboricus*. It can also be a tertiary or quaternary parasite on any of these insects when they themselves are secondary or tertiary. This probably explains its success in becoming practically the only parasites of *caffeina* after control is effected and it may be the weakness of the whole complex, since it tends to produce a host controlled by one parasite only.

The known possible relationships of the two hosts and their parasites are shown diagramatically in Fig. 5. It is possible, however, that some which are shown as primary may be only obligate secondaries, in which the remains of the primary parasite have escaped detection.

Close collaboration has been maintained throughout the year with Mr. Kirkpatrick who is working on the same problem in Amani.

Antestia.—Studies on the seasonal incidence of *Antestia* and of its parasite *Corioxenos* have continued throughout the year, on the Station and on certain native plantations in the Arusha and Uru districts; the two latter in collaboration with Mr. Cairns and Mr. Curry respectively. The tentative conclusions arrived at are as follows: *Antestia* tends to increase in numbers only during the hot dry weather of November to March. Its parasite *Corioxenos* appears to depend first upon a rather high pupulation density of *Antestia* to be effective, but a fairly high parasitism is maintained throughout the cold weather in shaded plantations; this reached an average of nearly 50 per cent in the Arusha district and over 40 per cent in the Uru district. On the Station, where most of the coffee is unshaded, and the infestation of *Antestia* was very low, parasitism by *Corioxenos* was negligible during the cold weather, though it had been fairly high (22 per cent) during February, when the *Antestia* population was high also. It does not appear that either arsenite baiting or pyrethrum dusting adversely affects the *Corioxenos* population except indirectly by lowering the population density of *Antestia*.

Work on the correlation of the number of *Antestia* with the percentage damage of crop has continued. In the main the figures obtained confirm the tentative correlation given in last year's report, but final figures have not yet been worked out.

Tests with inert dusts impregnated with an extract of pyrethrum in petrol have been carried out on infestations of *Antestia* in the field at Arusha and Marangu. The results were disappointing. Tests were also carried out at Silverdale Estate with mixture of pyrethrum dust and tobacco dust, which showed that this mixture cannot be recommended; the tobacco dust appears to act merely as an inert diluent. The same conclusion had been arrived at by the Kenya Department of Agriculture.

Thrips.—High temperatures in February and early March 1939 led to a small outbreak of thrips on the Station coffee; spraying was necessary in March on some areas. Since conditions indicated an outbreak in early 1940 a warning circular was issued in November. Thrips was reported from various places in December and spraying was necessary on the Station in early February.

Other Crops

A small experiment on maize seed protection was carried out at Kindi. Samples of seed in triplicate were treated with various materials and then planted in dry soil: the three areas were then irrigated after one and two weeks' dry weather. The intention was to leave the third plot for three weeks, but owing to a mistake it was irrigated after two weeks. Small samples were also treated and germinated in petrie dishes. In the field paris green and lime, and sodium fluoride gave the highest percentage germinations (70 per cent), arsenate of lead, sulphur and paradichlorbenzene following with 60 to 63 per cent. Controls, untreated, gave 56 per cent germination. The cause of low germination of maize seed which has remained for a period in dry soil was not established. Laboratory tests of these materials gave a considerably reduced germination with the first two of these materials; possibly owing to the much greater concentration of deleterious substances in the dishes used. Arsenate of lead is tentatively recommended.

Lyamungu,
March 1940.

F. B. Notley,
Entomologist